CARDIOVASCULAR FITNESS: DEVELOPING A TESTING GUIDELINE

EXECUTIVE DEVELOPMENT

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions or writings of another.

Signed_____

ABSTRACT

This research project used the action research method to evaluate cardiovascular fitness testing equipment and protocols, along with fitness testing facilities, to develop a Standard Operating Procedure on cardiovascular fitness testing for the Park City Fire Service District. The PCFSD had no formal wellness program, and establishing this test supplemented the annual physical, putting PCFSD one step closer to compliance with NFPA 1582. Utah fire departments were surveyed and interviews conducted with fitness professionals to answer the research questions. The research questions were:

- What do other fire departments consider an acceptable level of cardiovascular fitness?
- What types of cardiovascular capacity testing are other departments currently using?
- What types of cardiovascular capacity testing are used by sports teams?
- What private and public sector facilities are used by other departments to assist in cardiovascular capacity testing?

The results of the research led to adopting and implementing an annual cardiovascular fitness test. The fitness test is monitored by a fitness coordinator and will be modified as the needs of the organization and future research requires.

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INTRODUCTION

The Park City Fire Service District (PCFSD) transitioned from strictly volunteer to full-time and part-time paid in early 1983. In the past twenty years it has grown from seven full-time firefighters to over sixty full-time firefighters, with the majority of that growth in the last ten years. In the next two years twenty additional employees will be hired. As a relatively young department with the majority of employees under the age of forty, we have the perfect opportunity to adopt health-oriented standards that will ensure the long-term health and survivability of each of those employees. The long-range goal (five years) will be to be in full compliance with National Fire Protection Agency (NFPA) standard 1582 (2003) Comprehensive Occupational Medical Programs for Fire Departments, and 1583 (2000) Health Related Fitness Programs for Fire Fighters. The near term goal and the goal of this research project is to develop and adopt a cardiovascular fitness test. This test will be the first and most important component of the five-part fitness test recommended in NFPA 1582 (2003).

The problem is that the PCFSD does not have a program for evaluating the cardiovascular fitness of firefighters. This has resulted in personal risk to each employee when they are asked to perform strenuous emergency scene operations where decreased cardiovascular capacity could result in severe cardiac injury or death.

The purpose of this research is to identify and create a standard operating guideline outlining an instrument(s) to evaluate cardiovascular capacity of firefighters and their ability to perform job-related functions.

The action research method was used to answer the problem statement. This method was selected because a guideline was created. This guideline will be used and expanded upon as the PCFSD continues to increase and improve its wellness program.

The following research questions were used to gather information relevant to creating the cardiovascular fitness standard operating procedure:

1. What do other fire departments consider an acceptable minimum level of cardiovascular fitness?
2. What types of cardiovascular capacity testing are other departments currently using?
3. What types of cardiovascular capacity testing is used by sports teams?
4. What private and public sector facilities are used by other departments to assist in cardiovascular capacity testing?

BACKROUND AND SIGNIFICANCE

The Park City Fire Service District encompasses an area of 104 square miles. Within the fire district boundaries lay the entire town of Park City and the western portion of Summit County. The area lies in the Wastatch Mountains just east of Salt Lake City. Although the area was founded in the late 1800's as a silver mining town, the silver is long gone and the local economy revolves around recreation. Skiing has been a favorite activity for adventuresome folks since the town was founded. It wasn't until the 1960's that the town saw an economic revival with the opening of the Park City Ski Resort. The town now plays host to three world-class ski resorts. If you ask any local what brought them to Park City they will tell you it was the skiing. If you ask them why they stay they

will tell you it is the beautiful mountain summers. The beautiful summers encourage locals and tourists alike to engage in a myriad of outdoor athletic adventures.

In the last twenty years the full-time, year-round population of the district has risen from a modest 6000 people to a bustling 30,000 plus. The daytime population swells three fold daily as blue-collar workers who cannot afford to live within the fire district borders drive in to work at the various hotels, restaurants, and resorts that support the tourist driven economy. In addition, the town supports a 21,200 plus pillow base of overnight lodging facilities and over 5,500 second homes (Park City, 2004).

What do all of the full-time and part-time residents, tourists and firefighters have in common? They have a love for the outdoors and recreation. As such, this area is inhabited and visited by a population of athletic, mostly healthy, activity seeking individuals and families. In this area, as in other areas but more so, the customers of the fire district expect their firefighters to be in shape and healthy. An out-of-shape, overweight firefighter sticks out like a sore thumb in this town of ultra healthy outdoors enthusiasts.

Starting in the early 1980's, shortly after PCFSD transitioned from volunteer to full-and part-time paid, annual physical agility tests and physicals were begun. Chief Kelly Gee, long a supporter of physical fitness, was innovative in requiring all employees to pass an annual fire task related agility test for continued employment. The test has morphed over the years, and is now closely related to the firefighter combat challenge. Although this test is job skill related it is not a true test of actual personal health. The average firefighter finishes the test in three minutes and thirty seconds. With the adoption of NFPA 1582 (2003), NFPA 1583 (2000), and the International Association of Fire

Fighters (IAFF)/ International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness-Fitness Initiative (FSJLMWFI) (International Association of Fire Fighters [IAFF], 2000) , it has become obvious that the existing physical agility test needs to be supplemented with a complete health and wellness program.

A complete health and wellness program is the ultimate goal. The immediate goal is to begin testing and monitoring cardiovascular health. Monitoring and testing for cardiovascular health will accomplish two immediate goals. It will assist the United States Fire Administration (USFA) in meeting its number three operational objective "Reduce the loss of life from fire of firefighters" (National Fire Academy--Applied Research Guidelines). It will accomplish this by identifying at-risk employees. Employees whose cardiovascular conditioning has fallen to unacceptable and borderline unhealthy levels are more at risk of dying on the fire ground of cardiovascular accidents. Secondly, it will put the PCFSD one step closer to becoming in compliance with NFPA 1582 (2003) and 1583 (2000).

LITERATURE REVIEW

A literature review was completed using the Learning Resource Center, the Internet, fitness manuals, and personal interviews. In this section I will disclose the body of knowledge I discovered in the following areas:

1. Nature of the Problem
2. Testing Methodology
3. Discovery of Existing Tests
4. Test Selection

5. Acceptable Levels of Cardiovascular Fitness

Nature of the Problem

The National Fire Data Center has tracked firefighter fatalities for over two decades (U.S. Fire Administration, n.d.). In that time the number one cause of firefighter fatalities has been cardiac arrest. The medical community has gathered and published thousands of documents relating to the causes of cardiac arrest. The risk factors (obesity, smoking, heredity, etc…) are common knowledge and will not be examined here. Firefighter fatalities due to heart attack have remained constant at 44% of all firefighter fatalities over the last 20 years (FEMA, 2002). That rate is twice that of all police fatalities, and three times the rate of all other occupational fatalities combined (FEMA, 2002). According to the origin and development page of NFPA 1583 (2000), 50% of all firefighter fatalities are due to heart attacks. In addition, "Over weight, out-of-shape fire fighters are an accident waiting to happen. The multiple stress factors and rigors of the profession require fire fighters to be medically and physically fit in order to perform the required tasks" (NFPA, 1583, p. 1).

The origin and development paragraphs of NFPA 1583 (2000) go on to say, "A health related fitness program will contribute significantly to reducing fire fighter fatalities and injuries." (NFPA, 1583, p. 1)

NFPA 1583 (2000) outlines a fitness program that individual fire departments can follow to promote healthy firefighters. In section 4.4 the standard recommends annual testing for aerobic capacity. (NFPA, 1583, p.6)

Very few people will argue with a chief when he says his most valuable asset is his employees. This sentiment is put on paper in annex A of NFPA 1582 (2003), "The

most vital resource of any fire department is its members." (NFPA, 1582, p. 24) However, historically very few departments have been willing to devote the time, resources, and money needed to properly institute a wellness program. In the origin and development paragraphs of NFPA 1582 (2003) there is a statement that sums up the truth about a wellness program. "While some say that the cost of medical exams is too high, one must measure that against long-term job related illnesses, injuries, and fatality costs." (NFPA, 1582, p. 1) It is impossible to put a value on a person's life. We know that dying while firefighting is three times more likely than in any other occupation. Our organization will be remiss if we do not recognize this and implement programs to prevent it.

We have been remiss for over twenty years, and we are not alone. An article in Fire Chief magazine opens with the following statement:

> In 1980, the International City / County Management Association released Municipal Innovation Report No. 31, which documented the savings of cities with physically fit firefighters. Yet 17 years later, controversy and doubt regarding fitness standards continue to impede any systematic approach to universal acceptance and agreement on the role of physical fitness within the nation's fire service. (Davis, Gerkin, 1997, p. 24)

The article goes on to remind its readers not to lose sight of the fact the nation's fire services need to be fit in order to accomplish the difficult tasks inherent in firefighting. It also reminds its readers that each firefighter must not only perform while employed, but also live to see a long retirement.

Chapter 8 of NFPA 1582 (2003) is devoted to annual fitness evaluations of firefighters. The standard recommends an annual fitness evaluation. Section 8.2.1 states, "The fitness evaluation shall be performed on an annual basis." Section 8.2.1.1 goes on to say, "An evaluation of aerobic capacity shall be conducted using either a stairmill or treadmill protocol." (NFPA, 1582, p.15)

Testing Methodology

The American College of Sports Medicine's (ACSM) Guidelines for Exercise Testing and Prescription is a reference book for physicians and allied health professionals. Allied health professionals include fitness and clinical exercise professionals. The book is the best selling, mostly widely used reference text in the world (ACSM-VI, 2000). According to an interview with Traci Thompson, MS, Director of the PEAK Academy at the University of Utah (personal communication, August 20, 2004), the ACSM's Guideline for Exercise Testing and Prescription is the gold standard by which all health care professionals turn to for cardiac fitness testing.

ACSM defines cardio respiratory fitness as follows. "Cardio respiratory fitness is related to the ability to perform large muscle, dynamic, moderate to high intensity exercise for prolonged periods" (ACSM-VI, 2000, p. 68). ACSM continues on to define why cardio respiratory fitness is health related. Individuals who rarely exercise are at a substantially higher risk of an early exit from this world from all kinds of health concerns, but mostly from cardiovascular disease. Individuals who exercise regularly are much less likely to die an early death. Individuals with high levels of cardiovascular fitness are pursuers of higher levels of regular physical activity. Thus, the circle is complete; higher regular activity equals better health (ACSM-VI, 2000, p.68).

Having defined the need for improved cardio respiratory fitness, the next question is how to measure it. According to ASCM-VI (2000, p. 68), "Maximal oxygen uptake (VO_{2max}) is accepted as the criterion measure of cardio respiratory fitness." A firefighter's VO_{2max} is a measurement of millimeters of oxygen consumed per minute per kilogram of body weight (Loy, 2001, p. 14). VO_{2max} is measured using open-circuit spirometry at maximal cardiac output. The measurement is taken by modern testing equipment that gives detailed printouts of test results. The test must be performed in a clinical setting due to the cost of equipment, the inherent health risk of functioning at maximum heart rate, and the number of people required to administer the test. The cost per person to run this test is upwards of $500 per person. ACSM-VI (2000, p. 69) recommends maximal VO_{2max} testing for healthy individuals concerned about coronary heart disease. An alternative to maximal $VO_{2\ max}$ testing is sub maximal VO_{2max} testing. ACSM-VI (2000, p. 69) recommends sub maximal testing "when direct measurement of VO_{2max} is not feasible or desirable". For the vast majority of health and fitness professionals maximal VO_{2max} testing is not practical. Maximal VO_{2max} testing is not desirable when budget is restricted, high risk is not desired, and less time and effort are available.

Discovery of Existing Tests

ACSM-VI (2000, p. 70) has divided methods of exercising modes to measure maximal and sub maximal VO_{2max} into four categories. The four categories are field tests, motor driven treadmills, mechanically braked cycle ergometers, and step testing. Within each category there are many exercise variations all designed to achieve the same result, measure or estimate VO_{2max}.

Field tests are performed by having an individual run a set distance or for a set time at his or her maximal effort. All of these tests are considered sub maximal because of the inability of health care professionals to monitor with cumbersome medical devices the individual while he or she is running. Measuring the volume and gasses during expirations and inhalations is impossible while running outdoors;with today's technology. For these tests to be accurate the individual must run at his or her maximal output. Cardiac monitoring is not easily monitored while running outdoors; thus, the individual is on his honor that maximal effort was put forth. Less than maximal effort will skew the test results. However, several field tests have been developed using less than maximal effort. These tests have been proven to be good estimators of VO_{2max}. A popular sub maximal test is the Rockport One-Mile Fitness Walking Test. This test requires an individual to walk a mile as fast as he or she can for one mile. During the last quarter mile the individual's heart rate is measured. Using a table taking into consideration weight, age, gender, walk time, and heart rate the individual's VO_{2max} is estimated (Lecuyer, 1998). Another sub maximal field test is the One-Mile Jogging Test. After warming up the individual jogs for one mile around a track at a comfortable pace, but no faster than eight minutes per mile for men and nine minutes per mile for women. Immediately upon concluding the mile the individual's pulse and time to complete are recorded. Using a table and a formula the individual's VO_{2max} is estimated (Hammer, 2003).

Treadmill testing is extremely popular for both maximal and sub maximal VO_{2max} testing. The Bruce Treadmill Test remains the most popular with an estimated 71% of all treadmill tests using this protocol (ExRx, 2004). The Bruce test requires the participant to

start on a treadmill walking with increases in slope and pace every three minutes. Ideally, the test should last between 9-15 minutes. The test is stopped when the individual is unable to continue. The time recorded when the individual stops is inserted into a formula. Resolving the equation gives the estimated VO_{2max} (Successful Coaching [SC], 2004). The Gerkin Treadmill Protocol is recommended in the FSJLMWFI. In this test the individual walks for three minutes at 3 mph to warm up. At the end of the warm-up the speed is increased to 4.5 mph and the test starts. After one minute the slope is increased 2%, after two minutes the speed is increased .5 mph. This process continues with slope increasing every odd minute 2%, and speed increasing every even minute .5 mph, until heart rate reaches 85% of estimated maximum. The final time is recorded and referenced to conversion table to determine an estimated VO_{2max} (IAFF, 2000, p. A-10). The Gerkin test is used in both the Phoenix and Mesa Fire Departments. Another common treadmill test is the Balke Treadmill Protocol. Exercise Prescription (ExRx, 2004) estimates 10% of all treadmill tests use this protocol. The Balke Treadmill Protocol is a walking test. The individual walks at 3.3 mph (3 mph for women) for one minute at 0 % grade, after one minute the grade is raised 2%, after each additional minute the slope is increased an additional 1%. Ideally the test will last from 9 to 15 minutes. The recorded time when the individual can no longer continue is plugged into a formula to calculate $V0_{2max}$ (SC, 2004). The Astrand Treadmill Test is a running treadmill test that uses a constant speed but changes slope at regular intervals. The individual runs for three minutes at 5 mph at 0% slope, at the three minute interval the slope is increased to 2.5%, each 2 minutes following the slope is increased another 2.5%. The test is over when the individual can no longer continue. VO_{2max} is calculated by entering the time at which the individual could

no longer continue into a formula. Resolving the formula gives an estimation of VO_{2max} (SC, 2004). Many other tests exist but they are only variations of the ones already covered.

Cycle Ergometer testing uses a stationary bike to estimate VO_{2max}. A common cycle Ergometer Test is the YMCA Submaximal Bicycle Test. The individual pedals a stationary bike at 50 cycles per minute. When the heart rate reaches a predetermined percentage of estimated maximum the tension is increased. This process continues until 75% of estimated maximum heart rate is achieved. The time at which 75% of estimated max is achieved is recorded and then plugged into a formula so that VO_{2max} may be calculated (Cotton, 1996, p. 177). The Astrand Cycle Ergometer Test also uses a stationary bike to estimate VO_{2max}. In this test the individual pedals at a constant rate at a fixed resistance for seven minutes. Heart rate is measured every minute. The results are then compared to a fixed chart to estimate VO_{2max} (Robs Home of Sports Fitness Testing, 2004). Because of reduced movement in the arms and thorax, medical monitoring necessary to receive accurate results is easier to perform on a cycle ergometer. Unfortunately, due to the unfamiliar mode of exercise, many individuals will experience leg fatigue prior to completing the test (ACSM, 2000, p. 97).

The final mode of testing looked at is step testing. Step testing requires the individual to simulate the motions of climbing stairs by either stepping onto and then off of a fixed height object over and over again, or using a stairmill machine to continually climb a never-ending stair. A very common test is the Harvard Step Test. In this test a metronome is used to maintain constant pace while the individual steps onto and off of a 45cm high stool once every two seconds. This cycle continues for five minutes. One

minute after finishing the five-minute test the individual's pulse is taken and recorded. Two minutes after finishing the test the pulse is recorded again. Three minutes after finishing the test the individual's pulse is recorded a third time. The three recorded pulses are then entered into a fitness calculator. The calculator estimates VO_{2max} (SC, 2004). The Queens College Step Test is similar to the Harvard Step Test. The individual steps onto then off of a 41.3cm high step 24 times a minute (22 for females) for three minutes. Five seconds after completing the test the individual's heartbeats are counted for fifteen seconds. The resulting number is entered into a fitness calculator that estimates the individual's VO_{2max} (SC, 2004). Several other tests, like the Tecumseh and YMCA Sub Maximal Step Test are used by fitness trainers and follow similar protocols. An alternative to a fixed step test is a stairmill test. A stairmill is similar to a treadmill except the individual climbs a never-ending stair. The FDNY Stairmill Protocol requires the individual to warm up on the stairmill for thirty seconds, then maintain a constant sixty steps a minute pace for three minutes. During the final fifteen seconds the individual's pulse is recorded. The final pulse rate combined with the individual's age and weight are entered into a formula (one for men, one for women) that estimates VO_{2max} (IAFF, 2000, p. A-11).

Test Selection

The next step to picking an appropriate test is to look at the most important characteristics of each test. "The three most important characteristics of a test are validity, reliability, and objectivity" (Semenick, 1994, p.250). The single most important of the three is validity. Does the test measure what it is supposed to measure? To be a valid test for PCSFD the test must accurately measure VO_{2max}. The test must be reliable.

To be reliable the test must be repeatable when all factors are equal and achieve the same results. Some reasons that cause all factors to not be equal are scorers who grade differently. Sometimes the testing instrument fails or is not calibrated properly. Other times the firefighter tested fails to give maximum effort during the examination process, or the tester may fail to follow standardized testing procedures. Scorers must maintain their objectivity during testing. A scorer with a close personal relationship to the tested individual may inflate test results to make his friend look better. Different scorers may not agree on the magnitude of a score. In addition to choosing the most valid and reliable test, several other factors should also be taken into consideration. One of the factors is experience; is the test appropriate for the historic duties of firefighting. Another is environmental; performing the test outdoors for one individual in the middle of a Park City winter and for another in the dead of summer will not produce reliable results. Finally the test must be unbiased; asking a firefighter to perform a cycle test whom has never cycled will not generate accurate results. In selecting valid, reliable, and objective results the tester must not only have a thorough understanding of exercise physiology, but also must be intimately familiar with the field of firefighting (Semenick, 1994, pp. 150-151).

In Fort Worth, Texas two doctors compared the VO_{2max} of firefighters performing maximal tests on a treadmill and a stairmill. They summarized that stair climbing is task-specific for firefighters. Thus, when making a recommendation for desired fitness levels, a more accurate level would be determined when desired results are based on a stairmill modality. The results of the study showed that VO_{2max} was significantly lower (average 7%) for firefighters on a stairmill than a treadmill. In addition to the recommendations on

fitness levels they summarized that firefighters training on a stairmill will be better suited to perform fire ground tasks, “Specificity of training is a well-established concept in exercise training and should be considered here” (Ben-Erza & Verstraete, 1988, pp.103-105).

Acceptable Levels of Cardiovascular Fitness

According to Loy (2001, p. 14) an acceptable level of cardiovascular fitness is one that allows the firefighter to perform the most strenuous of fire ground activities at 85% of his or her VO_{2max}. In 1992 two Canadian scientists published a study in the Canadian Journal of Sports Science. Loy (2001, p.14) referenced this study in his article for Fire Chief magazine. According to the Canadian study the most demanding of fire ground activities require a VO_2 expenditure of 41.5. In the study the most demanding tasks were also the most common. The average time to perform these demanding tasks was ten minutes. Loy continues on to say if all firefighters on the department have a VO_{2max} of 49 or higher, then the most demanding tasks will be performed at 85% of VO_{2max} (49 x 85% = 41.65). Hammer (2003, p. 95) reinforced this theory in his article for Firehouse magazine when he published a chart listing the VO_2 expenditures for common fire ground activities. The most demanding task, climbing stairs with a high-rise pack, had a VO_2 expenditure of 44. Hammer goes on to say, “Since the maximum effort of fighting fires is near 44 mL/kg/min, it would make sense to have a VO_{2max} above that.” Davis (1995, p.17) in his article for Fire Chief magazine makes this quote:

> Since the requirements of structural firefighting are not going to change as a function of age, race or sex, and since there is a considerable body of scientific evidence to support a threshold level of fitness at a maximal oxygen uptake of 45

millimeters per kilogram of body weight per minute, I used this figure in my analysis.

Davis (1995, p.17) uses data collected over the last ten years of testing members of the Phoenix Fire Department (PFD) to make some astute observations. Davis observed that the effects of age are inevitable. He observed in the adult civilian population VO_{2max} dropped 1% per year or 10% every decade. In the PFD, an organization highly regarded for its proactive approach to fitness, the affects of fitness slowed the process to 6% per decade but could not eliminate the effects of aging. Davis concluded that if a firefighter were to complete a 25 year career, he must remain physically active his entire career and start his career with a VO_{2max} of at least 52.

Not all fire ground tasks are performed at the most demanding level. Many are performed at a lesser level. In a chart referenced by Hammer (2003, p. 95) other common fire ground tasks like pitched roof ventilation, pike pole work, victim drag, and extrication all required VO_2 expenditures in the 20's. To be able to perform these operations continually over the duration of a structure fire requires a fire fighter to work at 50% of his VO_{2max}. This reinforces the theory that a firefighter must have a VO_{2max} in the mid to high 40's to be effective on the fire ground (Loy, 2001, p. 14).

PROCEDURES

Research Methodology

This research project employed the action research method to develop a standard operating procedure on cardiovascular fitness testing for the PCFSD. An evaluation of existing material started with a search of all material available at the Learning Resource Center (LRC) at the National Fire Academy (NFA) in Emmitsberg, MD. This search was

performed in early April 2004. The search at the LRC revealed a couple of previously written applied research papers and several journal articles. The LRC review was supplemented with a search for materials at the main PCFSD firehouse library. The PCFSD search was conducted in late April 2004. From the complete set of up-to-date NFPA guidelines maintained by the PCFSD Fire Marshal NFPA sections 1582 and 1583 were copied. From a reference in NFPA 1582 the need to purchase the FSJLMWFI was recognized. A copy of the initiative was purchased from the IAFC web site.

Over the course of the summer of 2004 the Internet was searched continuously for more generic information involving cardiovascular fitness testing in general. This search revealed numerous web sites that provided extensive data on maximal and sub maximal VO_{2max} testing protocols. These sites are referenced heavily in the literature review. On the Internet the web sites of numerous large metropolitan fire departments in the United States were reviewed. Many of these departments have extensive web sites outlining the wellness programs of their departments. The web site search was followed up with phone calls to some of the departments whose web sites indicated they might be doing cardiovascular fitness testing. Some of the departments called were Seattle, Sacramento, Las Vegas, and Mesa, AZ. With the exception of Mesa none of the larger departments were doing mandatory cardiovascular fitness testing.

Interviews

I conducted several interviews to answer the research questions. My interview subjects mostly came via recommendations from professional and collegiate sports teams, and fire department administrators who were presently performing VO_{2max} testing. One interview subject came highly recommended from a coworker who attended (on my

behalf) the Phoenix Fire Department Fitness and Wellness Symposium in late June of 2004.

On September 10, 2004 I had my first of several phone and e-mail contacts with Steve Giardini, the civilian Wellness Program Facilitator of the Mesa Fire Department (MFD). Steve has 17 years experience in the field of fire department fitness and wellness. Steve is a certified Peer Fitness Trainer by the American Council on Exercise (ACE), and is certified by Health Matrix as a Fitness Coordinator. Additionally, Steve is certified by the ACSM as a Health Fitness Instructor. I was referred to Steve by the administration office of the MFD. I asked Steve to explain why and how he chose the sub maximal VO testing protocol used by MFD. I also asked him to explain how, when, and where the testing took place. Additionally, I asked Steve who administered the test and what their qualifications were.

I interviewed Dr. William Lee on September 10, 2004. Dr. Lee is the Medical Director of Profile Health. Profile Health is under contract to provide a wellness center for the Phoenix Fire Department (PFD). A coworker who attended the PFD Fitness and Wellness Symposium referred Dr. Lee to me. PFD has long been considered one of the premiere and progressive fire departments in the United States. I asked Dr. Lee whether he was performing VO_{2max} tests on Phoenix firefighters. I asked Dr. Lee what test he would implement given the opportunity.

On August 20, 2004 I conducted a personal interview with Traci Thompson, MS, the director of the PEAK Academy on the campus of the University of Utah. The PEAK Academy is a division of the Exercise and Sport Science, College of Health. The Peak Academy has been performing fitness evaluations for faculty, staff, students, and athletes

at the University of Utah for over 17 years. Bill Bean, the head trainer for the University of Utah football team, referred me to Traci. I asked Traci if she performed VO_{2max} testing, what protocols the PEAK academy used, what the differences were in the various VO_{2max} tests, which VO_{2max} test the Peak Academy recommended and why. I inquired if the Peak Academy was interested in performing the test for the PCFSD.

On September 15, 2004 I conducted a phone interview with Mark McKown, the Strength and Conditioning Coach of the Utah Jazz. Gary Briggs, the head trainer for the Utah Jazz, referred me to Mark McKown. The Utah Jazz are a National Basketball Association franchise based in Salt Lake City, UT. I asked Mark whether the Utah Jazz performed VO_{2max} testing on the professional athletes under contract with the team. I enquired whether the test was maximal or sub maximal, and whether it was performed in house or out of house

In the results of the survey for this research paper I discovered that three departments in northern Utah carry out their annual fitness testing at the Cardiac Fitness Unit of McKay Dee Hospital. The director of the institute is Ann Walters. Ann has a master's degree in exercise physiology, is a registered clinical exercise physiologist, and is a member of the American Association of Cardiovascular and Pulmonary Rehabilitation. I interviewed Ann by phone on September 24, 2004. I asked Ann which sub maximal testing protocol the institute used when checking cardio respiratory fitness. I asked her the reasons this test was selected. I asked her if she felt the test would meet the requirements of NFPA 1582.

Surveys

In order to answer the second research question I conducted a survey of all full-time and combination full-time fire departments in the state of Utah. I started the survey in mid September 2004 and finished by the end of the month. Although there are over 260 fire departments in Utah, only twenty-seven of them employ full-time employees. Because Utah is a mostly rural state and the volunteer agencies are mostly small, under funded, and highly likely to not be performing wellness checks on their employees, I felt the return on investment of time to survey them was not practical. I conducted a phone survey of each of the twenty-seven full-time and combination departments to ensure a compliance ratio of 100%. I conducted the survey by first calling the main number for each department and then asking to speak with the department member over the fitness and wellness program. In most instances I ended up talking with the fire chief. In the larger departments I was either directed to a battalion chief or an assistant chief over training, medical or occasionally wellness. I asked every department if they were performing VO_{2max} testing annually for each employee. If yes I followed up with three additional questions. One: Was the test mandatory? Two: What type of test was it? Three: What testing protocol were they using? The results are tabulated in appendix B.

RESULTS

Research Question 1

What do other fire departments consider an acceptable minimum level of cardiovascular fitness?

None of the departments surveyed set a minimum level as an acceptable standard for cardiovascular fitness. Of the few departments surveyed that do test cardiovascular

fitness, the initial test result is used for a base line. Then subsequent tests are used to determine whether the firefighter's cardiovascular health is improving or decreasing. A department peer fitness trainer uses the test results to set up or modify a training program. The program is designed to improve or maintain the firefighter's cardiovascular fitness. I was only able to locate one department that used the results of a sub maximal VO_{2max} test to gauge the member's overall health and ability to perform. The MFD uses a formula that combines scores in aerobic condition, strength, endurance, body fat, and flexibility to determine whether an individual is fit to perform. The score sheet is proprietary but is available for purchase through Health Metrics Incorporated. Although I was unable to answer this question as phrased, I was able to answer it with information garnered in the literature review. At least three authors agreed a minimum acceptable VO_{2max} for a suppression firefighter should be at least 45mL/kg/min.

Research Question 2

What types of cardiovascular capacity testing are other departments currently using?

In Utah only three departments are currently performing cardiovascular capacity testing. All three departments use the University of Massachusetts Four Minute Walk Test. The Mesa and Phoenix Fire Departments both use the Gerkin Treadmill protocol. NFPA 1582 (2003, p.15) recommends a treadmill or stairmill protocol. The FSJLMWFI recommends a FDNY Stairmill test or a Gerkin Treadmill Test (IAFF, 2000, p. A-4). To decide which of the two tests would be appropriate for PCFSD I compared the results of the literature review with the recommendations of the PEAK Academy (Ben-Erza and Verstraete, 1988, pp.103-105)(Thompson, Personal Interview).

Research Question 3

What types of cardiovascular capacity testing is used by sports teams?

Professional sports teams use a maximal VO_{2max} test. They do this for several reasons. They have a significant financial interest in the health of their players. Although long-term health is not of immediate concern, short-term health is. The team expects the player to maintain top physical condition for the length of his or her contract. The test is to ensure the player is staying in top shape. The teams are paying significant sums of money for a professional player; thus, they are ensuring the player will be able to withstand the rigors of a long season. The team has a limited number of players and a seemingly limitless supply of money: thus, the time it takes to complete the test and the amount it costs are of no concern.

Research Question 4

What private and public sector facilities are used by other departments to assist in cardiovascular capacity testing?

Private companies like Well Source Inc. and Health Metrics Inc have developed resources like the health risk appraisal form. These forms and associated data simplify the process of assembling testing protocols. These companies assist in evaluating the scores from cardiovascular capacity tests and incorporating their significance in an overall fitness compilation. Teaching hospitals like McKay Dee in Ogden and the University of Utah in Salt Lake City are more than happy to evaluate firefighters for a nominal fee. The evaluation has the dual benefit of providing a valuable service to the employees of local fire departments and offering training opportunities for graduate students in the fields of sports fitness.

Survey Results

The telephone survey was designed to answer the second research question. Twenty-six departments in the state of Utah were asked if they were currently performing cardiovascular fitness testing. Three departments responded in the affirmative. For the departments that responded in the negative there were no follow-up questions. The three departments that responded in the affirmative were asked what type of test they were using. All three departments responded with the same answer. In fact, all three departments were in the same region and were all using the same test administered at the same facility by the same facilitator.

Interview Results

In the interview with Traci Thompson, MS, I learned that the PEAK Academy regularly performs all types of sub maximal VO_{2max} tests. I learned that she and the PEAK Academy were proficient in all types of protocols and were willing and qualified to administer any published sub maximal VO_{2max} protocol. Traci was able to provide abundant information on VO_{2max} testing protocols, the differences of the various tests, and supplied me with or pointed me in the direction of several outstanding books that outlined the various tests. Those books are referenced in this research paper. Traci also made recommendations on several tests that she thought we should consider when setting up our testing protocols. At the time of the first interview Traci recommended a 1.5-mile walk protocol. She said she had good success with that protocol and said the firefighters would enjoy the outdoor atmosphere. Traci was very interested in working with firefighters and had previously solicited the Salt Lake City Fire Department to test with the PEAK Academy. In addition to performing sub maximal VO_{2max} tests the PEAK

Academy can provide and continually modify exercise programs for individuals wishing to improve their cardiovascular health.

Steve Giardini explained in detail the VO_{2max} testing performed by the MFD. The MFD uses the Gerkin Treadmill protocol as outlined in the FSJLMWFI (2000, p. A-9). MFD employees who are trained as Peer Fitness Trainers by ACE administer the test. The test is administered in the MFD fire stations. Steve explained in detail the intricacies and benefits of NFPA 1582 and 1583 and the FSJLMWFI. Steve explained how the results of the Gerkin Treadmill test are inserted into the Health Metrics Inc. health fitness pentagon along with the results of several strength, endurance, flexibility, and body fat tests to rate the overall fitness of a firefighter. The results of the Gerkin Treadmill test carry the most weight in the health fitness survey.

The interview with Mark McKown of the Utah Jazz garnered the following information. The Utah Jazz, an NBA franchise in SLC, performs maximal VO_{2max} testing on all of its players each year during training camp prior to the start of the basketball season. Doctors in a physician's office perform the test. The test is performed on a treadmill.

Dr. Lee of Profile Health explained in detail the wellness service he provides for PFD. Dr. Lee also highly recommended I read NFPA 1582 and 1583 as well as the FSJLMWFI. Although the PFD has an extensive wellness program they are not in compliance with the fitness-testing portion of NFPA 1582 and are not performing sub maximal VO_{2max} testing. Dr. Lee told me that PFD does utilize firefighters certified as peer fitness trainers and they are using the Gerkin Treadmill Protocol on a voluntary basis.

Ann Walters from The Cardiac Fitness Unit at McKay Dee Hospital uses a sub maximal walking test called the University of Massachusetts Single Stage Sub Maximal Walking Test. The test has a predicted accuracy of .92. Ann felt the test was appropriate because it allowed her to test a large quantity of firefighters in a relatively short time. She felt it is a test anybody can complete. She has been using the same test for 17 years and is able to track individuals' progress through their careers. She mentioned the test is applicable because everyone, including firefighters, must walk. Not everyone swims, bikes, or runs. The results of the walking test and several other tests are inserted into a health risk appraisal. The health risk appraisal is a proprietary document purchased from Well Source Inc. Each firefighter receives a copy of his or her wellness appraisal at the conclusion of his or her fitness evaluation. The test will meet the requirement of NFPA 1582, although it is not a recommended test from the FSJLMWFI.

Final Product

As a result of this research project the PCFSD has adopted and is implementing a Standard Operating Guideline (SOG) outlining and describing annual cardiovascular fitness testing. The fitness test will be completed at the PEAK Academy and will be administered by the director, Traci Thompson, MS, and graduate students under her direction. Although many testing protocols were examined the final decision was to use the Gerkin Treadmill Protocol. The test is administered the month following the birth month of each employee if the employee passes his or her annual physical. The employee receives a physical during his or her birth month. Both the physical and cardiovascular fitness test are spread out though a calendar year so as to not overload either of the entities. The Gerkin Treadmill protocol was selected because the PEAK Academy does

not have any stairmills. The Standard Operating Guideline for PCFSD cardiovascular fitness testing is included in Appendix A. PCFSD is excited about this first phase of the wellness program. We have received positive feedback from the employees who have participated in the trial runs. The employees whom have not yet tested seem motivated to improve their performance prior to testing and are kicking up their cardiovascular training. In general, fitness seems to have taken on a more important role in day-to-day activities. True results will be measured as data is compared in subsequent years.

DISCUSSION

In the study a specific level of VO_{2max} that would be considered a minimum acceptable level was never found. The study did find that at least four departments (Giardini, S. personal communication, September 10, 2004) (Walters, A. personal communication, September 24, 2004) used the raw number in combination with other fitness scores to establish a minimum acceptable level of fitness. The study found many departments that used the score as a baseline to monitor cardiovascular fitness performance for the course of a career (Walters, A. personal communication, September 24, 2004). The idea of a minimum acceptable level of VO_{2max} is well documented in literature, it is just not used in practice (Davis, 1995)(Hammer, 2003)(Loy, 2001). The research question revealed that the level of VO_{2max} could have a valuable place in initial hiring (Davis, 1995, p. 16). Ultimately, the idea of having a minimum score is not as important as performing the test to determine the score and using it as a baseline to monitor your own personal health. This is reinforced in the FSJLMWFI (IAFF, 2000, p. 1). In the FSJLMWFI there is no minimum score. The goal is: “The health, safety and longevity of all uniformed personnel” (IAFF, 2000, p. 2).

In the study, the types of tests other departments are using are discovered (Appendix A)(Giardini, personal communication, September 10, 2004)(Lee, personal communication, September 10, 2004). In the literature review the tests that we should be using is plainly revealed (IAFF, 2000, p. A-9). Fire departments who are setting up their wellness and fitness programs are wise to follow the direction set forth in the FSJLMWFI. Following the FSJLMWFI will put the department in compliance with NFPA 1582. Those that have set precedent and have years of existing data are wise to continue using the same cardiovascular fitness test, at least for existing employees. The progression of a firefighter's health should be the ultimate goal and is more important than the selection of a sub maximal VO_{2max} test. It is the goal, because the goal in FSJLMWFI is not punitive but to increase firefighter health and prevent cardiovascular injuries and death (IAFF, 2000, p. 1).

In comparing the VO_{2max} testing procedures of professional sports teams to fire departments, a basic philosophical difference was discovered. Whereas fire departments are concerned with reducing firefighter deaths and promoting long-term health (IAFF, 2000, p. 1), professional sports teams are concerned with optimizing current performance (McKown, personal communication, September 15, 2004). This basic philosophical difference made learning what professional sports teams do not suitable in trying to set up programs within the PCFSD. In comparing the VO_{2max} testing procedures of collegiate level teams to fire departments, the same philosophical differences were noted (McKown, personal communication, September 15, 2004). However, on the collegiate level the facilities used to perform the test are very suitable and adaptable to firefighter testing (Thompson, personal communication, August 20, 2004).

While some departments are performing in-house cardiovascular fitness tests, (Lee, personal communication, September 10, 2004)(Giardini, Personal communication, September 10, 2004) the majority surveyed use universities or teaching hospitals. The union of the fire service and these institutions is mutually beneficial. The institution receives a long-term client whom contributes to long-term studies and provides graduate students with testing subjects to further their education. (Thompson, personal communication, August 10, 2004) The fire service gains a professional, cost effective service with additional benefits of receiving exercise programs from professional fitness educators and graduate students.

In a perfect world all firefighters would be models of health, and individuals would be responsible for themselves. The underlying motivation to establish fitness testing was to ensure that all PCFSD firefighters would have long and fruitful careers and live long into their retirements. This research taught me that, although the outcome will be the same, the road to get there would be different. Fitness is a science. Like every other science, there are those who know a little and those who know a lot. The majority of firefighters don't know enough. Not only don't they know enough, they don't always have the motivation, information, or equipment necessary to maintain or improve their personal health. This research taught me to take advantage of the knowledge of others, and to not reinvent the wheel but adapt it to our own needs.

The implications of this study for the PCFSD are numerous. The organization will be expanding the benefits plan to the mutual advantage of both the employee and the employer. The implementation of cardiovascular fitness testing will put the organization one step closer to compliance with NFPA 1582. Likely increased fitness levels will

reduce sick leave by decreasing injuries and sickness. The implementation will pave the way for a complete wellness program. Each individual will supplement his or her firefighting knowledge with knowledge of his or her own personal health. Most importantly, the testing and subsequent promotion of better cardiac fitness will lessen the probability that this department will ever suffer its first line-of-duty death.

RECOMMENDATIONS

The continued success of the cardiovascular testing program is dependant on several factors. The process must continually be monitored to ensure compliance, to ensure validity, and to ensure results are being used to further the health of PCFSD firefighters. As the program moves forward we need to analyze the program's effectiveness and make changes to improve it. We need to continually monitor the field of cardiovascular fitness as scientists are constantly discovering new information.

To properly evaluate the success of this program a survey instrument needs to be completed by all members participating. As this test is designed to improve long-term health, test results must be compared annually.

A wellness coordinator must be appointed to monitor the cardiovascular fitness program, ensure compliance, and to address concerns as they arise.

The benefits of this research will be a healthier fire department. The department should enjoy a reduction in sick leave usage and a fire department that is more productive. Each individual will contribute more with reduced need for rehab on the emergency scene and shorter time to recover after significant expenditures of energy. Each member should enjoy a more productive career and live a longer healthier retirement.

The process of completing a wellness program is nearing completion for PCFSD. As this is the first phase of a five phased fitness evaluation (cardiovascular fitness, muscle strength, muscle endurance, body fat, and flexibility) we need to immediately start researching the implementation of the other four phases. Although cardiovascular fitness is the most important of the five tests it is still only one component of a complete fitness evaluation. The sooner the rest of the five tests are implemented the sooner the organization and its members will reap the benefits. There are no known detriments to increased cardiovascular and physical health.

Before beginning a research project about cardiovascular fitness, be thoroughly familiar with the standards that guide your field. In the field of firefighting NFPA is very progressive in adopting and publishing standards. Do not spend a lot of time surveying or interviewing fire departments that are not currently doing cardiovascular fitness testing. Nothing was learned from these departments. On the other hand, a wealth of knowledge is gleaned from organizations that are taking the initiative to be progressive and break ground for the rest of us.

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APPENDIX A

PARK CITY FIRE SERVICE DISTRICT	
STANDARD OPERATING GUIDELINES	
AFFILIATION:	***GENERAL OPERATIONS***
CHAPTER:	***CHAPTER 1 SECTION 21***
SUBJECT:	**CARDIOVASCULAR FITNESS TESTING**

I. PURPOSE

The purpose of this guideline is to outline the procedure for conducting an annual cardiovascular fitness test. The benefit of this test will be to establish a baseline cardiovascular fitness level and to provide direction to maintain or improve the baseline level.

II. EXPLANATION

Firefighting is a physically demanding profession that requires above average aerobic capacity. The tasks that firefighters are faced with on the fire ground are extremely demanding physically. These tasks must be performed without any warm-up and are typically performed under hostile work conditions. The ability of a firefighter to meet the demands of an emergency scene is significantly assisted by being physically fit. The Park City Fire Service District cardiovascular fitness evaluation is designed to assist firefighters in monitoring and maintaining or improving their cardiovascular fitness level.

The Park City Fire Service District has adopted the Gerkin Submaximal Graded Treadmill Test Protocol for testing cardiovascular fitness (Gerkin Protocol). The Gerkin Protocol is a recommended cardiovascular fitness test in the International Association of Fire Fighters and International Association of Fire Chiefs Fire Service Joint labor and Management Wellness/Fitness Initiative. The test will be performed at the PEAK Academy by a certified fitness trainer.

The Test is performed at the PEAK Academy on the University of Utah campus. The test shall be scheduled during the month immediately following the employee's birth month. The employee must complete and pass his annual medical evaluation during his birth month prior to taking the cardiovascular fitness test.

III. EQUIPMENT

The following equipment is necessary to complete the Gerkin Protocol.

1. Treadmill with heart rate monitor
2. Wrist watch style heart rate monitor
3. Gerkin Treadmill Test conversion table
4. Stopwatch

IV. SAFETY

Prior to conducting the Gerkin Protocol the fitness evaluator will certify that the individual being tested has received and passed his or her yearly medical evaluation. The fitness evaluator will take the individual's resting heart rate and blood pressure prior to the start of testing. If the heart rate exceeds 110 beats per minute or the blood pressure exceeds 160/100 mm Hg, the individual will be asked to relax in a quiet place for five minutes. If after five minutes heart rate and blood pressure are below the required minimums the test may start. If the rates are still above the required minimums the test will be cancelled and the individual shall be referred to a physician. If any of the following conditions exist prior to the test, the test shall be deferred:

- Chest pain during the absence of physical activity;
- Loss of consciousness;
- Loss of balance due to dizziness;
- Recent injury resulting in bone, joint, or muscle problems;
- Current prescribed drug that inhibits physical activity;
- Chronic infectious disease;
- Pregnancy;
- Any recent disorders that may be exacerbated by exercise; and / or
- Any other reason why the individual believes that he or she should not be physically evaluated.

If any of these conditions develop during the test, the test will cease immediately:

- Onset of angina like symptoms;
- Signs of poor perfusion;
- Failure of heart rate to increase with increase in exercise intensity;
- Individual requests evaluation to stop;
- Physical or verbal manifestations of severe fatigue;
- Failure of the testing equipment.
-

V. PROCEDURE

The testing protocol is explained to the individual. When the individual understands the directions he is asked to attach the heart rate monitor chest strap. The facilitator will ensure the two heart rate monitors (on the treadmill and wrist) read within one heartbeat of each other. The individual is instructed to straddle the belt of the treadmill until it begins to move. When the speed of the treadmill reaches 1 mph the individual is instructed to step onto the belt of the treadmill. The speed of the treadmill is increased to 3 mph at 0% grade. The stopwatch starts when the treadmill speed reaches 3 mph. At the three minute mark the speed is increased to 4.5 mph. At the four-minute mark the grade is increased to 2%. At the five-minute mark the speed is increased to 5 mph. At the six-minute mark the grade is increased to 4%. This cycle of increasing speed, .5 mph every odd minute and increasing grade 2% every even minute, continues until the individual's heart rate exceeds 85% of predicted maximal heart rate for 15 consecutive seconds. When the individual's heart rate exceeds 85% of predicted maximal heart rate for 15 seconds, or the eleven-minute mark, whichever comes first, the test is over. The facilitator shall record the time at which the test is over. The individual is instructed to stay on the treadmill for a minimum of three minutes at 0% grade and 3 mph for a cool down period.

Predicted maximal heart rate is determined using the Karvonen method:
Target heart rate = .85(220 – age – resting heart rate) + resting heart rate.
Resting heart rate is taken during the pretest safety session.

The time at which the time ended is compared to the chart on the next page to estimate VO_{2max}.

The individual's VO_{2max} score is recorded and placed into the employee's personnel file for future reference.

At the conclusion of the warm down period the fitness evaluator will confer with the individual and, if necessary, work with them to establish a training regime to help the individual improve his or her fitness level prior to the next test.

All results of cardiovascular fitness tests shall remain confidential between the employee and his or her evaluator.

SUBMAXIMAL TREADMILL TEST CONVERSION TABLE

STAGE	Time	VO2max
1	1:00	31.15
2.1	1:15	32.55
2.2	1:30	33.6
2.3	1:45	34.65
2.4	2:00	35.35
3.1	2:15	37.45
3.2	2:30	39.55
3.3	2:45	41.3
3.4	3:00	43.4
4.1	3:15	44.1
4.2	3:30	45.15
4.3	3:45	46.2
4.4	4:00	46.5
5.1	4:15	48.6
5.2	4:30	50
5.3	4:45	51.4
5.4	5:00	52.8
6.1	5:15	53.9
6.2	5:30	54.9
6.3	5:45	56
6.4	6:00	57
7.1	6:15	57.7
7.2	6:30	58.8
7.3	6:45	60.2
7.4	7:00	61.2
8.1	7:15	62.3
8.2	7:30	63.3
8.3	7:45	64
8.4	8:00	65
9.1	8:15	66.5
9.2	8:30	68.2
9.3	8:45	69
9.4	9:00	70.7
10.1	9:15	72.1
10.2	9:30	73.1
10.3	9:45	73.8
10.4	10:00	74.9
11.1	10:15	76.3
11.2	10:30	77.7
11.3	10:45	79.1
11.4	11:00	80

APPENDIX B

Utah Fire Department Cardiovascular Fitness Testing Survey

	Cardiovascular Fitness Testing	Testing Protocol Used	Mandatory
Bountiful City Fire Department	NO		
Cedar City Fire Department	NO		
Clearfield Fire Department	NO		
Clinton Fire Department	NO		
Layton City Fire Department	NO		
Logan City Fire Department	NO		
Midvale City Fire Department	NO		
Murray City Frie Department	NO		
North View Fire Department	NO		
Ogden City Fire Department	YES	Uof M walk test	YES
Orem City Fire Department	NO		
Provo City Fire Department	NO		
Roy City Fire Department	NO		
Salt Lake City Fire Department	NO		
Sandy City Fire Department	NO		
South Davis Fire Department	NO		
South Jordan Fire Department	NO		
South Ogden City Fire Department	YES	Uof M walk test	YES
South Salt Lake City Fire Department	NO		
St. George Fire Department	NO		
Syracuse Fire Department	NO		
Uniform Fire Authority of Greater Salt Lake	NO		
Wasatch County Fire Department	NO		
Weber County Fire District	YES	Uof M walk test	YES
West Jordan Fire Department	NO		
West Valley City Fire Department	NO		